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Exploring the Association between Green Innovation, Leadership and Environmental Performance: Mediation of Green Self-efficacy

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The persistent escalation of emissions emanating from the manufacturing industry gives rise to inefficiencies in environmental sustainability. This underscores the imperative incorporation of green technological innovation and leadership strategies to enhance environmental performance. This predicament is notably prevalent in the manufacturing sector of Saudi Arabia. Consequently, the current investigation centres on evaluating the influence of "green intellectual capital (GIC), green management innovation (GMI), green technology innovation (GTI), and green transformational leadership (GTL)" on a firm's environmental performance (EP). The study further integrates the mediating role of green self-efficacy (GSE) and the moderating effect of green empowerment (GE). Utilizing a quantitative approach, data were collected from 210 employees in the Saudi Arabian manufacturing sector through surveys, and subsequent statistical analyses were conducted. The findings of this study reveal that GIC, GMI, and GTL exert a significant impact on EP. In contrast, GTI demonstrates an insignificant influence on EP. However, the mediating role of GSE is deemed significant, and GE exhibits a noteworthy moderating effect in the relationship between GSE and EP. This study not only contributes empirically but also provides theoretical and practical implications, offering valuable insights to enhance environmental performance within the manufacturing sector under consideration.

Keywords: Green Technology Innovation; Environmental Performance; Green Management Innovation; Green Self-Efficacy; Green Transformational Leadership; Green Empowerment

1. Introduction

Manufacturing enterprises represent prominent contributors to global climate change. The emission of harmful gases from these entities leads to diverse environmental and health repercussions, underscoring the imperative for the adoption of green innovation (Trujillo-Gallego et al., 2021). Nevertheless, the reconciliation of environmental concerns with economic advantages has emerged as a formidable challenge for manufacturers in the contemporary era of globalization. Similarly, within the context of Saudi Arabia, the manufacturing sector is committed to enhancing its environmental performance by incorporating impactful and innovative green technology. In Saudi Arabia, the manufacturing sector continues to experience sustained growth, contributing approximately US$156 billion to the country's GDP in 2023. Furthermore, it is anticipated to exhibit an annual growth rate of 2.78% from 2023 to 2028 (Statista, 2023). Hence, the intensely competitive manufacturing sector has prompted numerous companies in Saudi Arabia to adopt green technology and management innovation, thereby enhancing their overall corporate performance. The Saudi Arabian government has concurrently introduced the "Saudi Green Initiative" (SGI), with the aim of achieving zero emissions by 2030 through a circular economy approach, facilitating the transition to a green economy (SGI, 2023).

According to Asiaei et al. (2023), GIC significantly impacts a firm's environmental performance. In this context, effective green training and development initiatives have proven to enhance GIC, underscoring the importance of incorporating a proficient leadership approach. Consequently, the adoption of GTL is anticipated to be efficacious in motivating employees and other relevant stakeholders to undertake crucial measures in achieving environmental objectives (Al-Ghazali et al., 2022). This leadership approach has a lasting impact on employees, resulting in enhanced EP. In this context, the significance of GSE among employees is pivotal for attaining the necessary environmental objectives (Guo et al., 2019). Thus, this study effectively assesses the influence of GTI and leadership on EP in the Saudi Arabian manufacturing sector. Additionally, it introduces novelty by examining the moderating effect of green empowerment on the relationship between green self-efficacy and EP.

This study encompasses three primary objectives: (a) assessing the influence of GIC, GMI, GTI, and GTL on EP; (b) examining the mediating role of GSE; and (c) investigating the moderating effect of green empowerment in the relationship between GSE and EP.

Hence, this current research holds both theoretical and practical significance, enhancing its efficacy. Notably, the study contributes to the literature by investigating the impact of green empowerment on the relationship between GSE and EP, thereby advancing existing knowledge. Additionally, the research expands the literature on green technology innovation within the Saudi Arabian manufacturing sector. Moreover, it serves as a catalyst for managerial action, encouraging the integration of GTI and GTL to enhance environmental performance. Furthermore, the study suggests the formulation of effective green policies to mitigate emissions from manufacturing firms.

2. Literature Review

Theoretical Background

The Natural Resource-Based View (NRBV) was initially formulated by Hart (1995) and this theoretical framework posits that organizations can employ diverse environmental protection strategies, focusing on pollution reduction, product stewardship, and the promotion of sustainable development, to gain a competitive advantage (Barney et al., 2010). The NRBV delineates three key strategic capabilities: pollution prevention, product stewardship, and sustainable development, emphasizing their pivotal role in driving environmental performance. Pollution prevention enables firms to abstain from releasing pollutants into the environment, advocating for environmental cleanliness. For instance, companies can optimize efficiency and reduce production costs by eliminating polluting factors from their processes. Product stewardship, extending beyond pollution prevention, involves integrating environmental responsibility throughout the firm's value chain. This entails engaging stakeholders in incorporating environmental considerations into product design and manufacturing processes. Lastly, a sustainable development strategy facilitates the establishment of environmentally friendly production methods designed for indefinite use (Barney et al., 2010). Hence, the Natural Resource-Based View's emphasis on the contingent nature of resources and capabilities has enabled researchers to establish a connection between the environmental and financial performances of firms (Barney et al., 2010). Numerous scholars have contributed to the theoretical literature on the NRBV by identifying diverse organizational capabilities capable of influencing the profitability outcomes associated with the adoption of pollution prevention strategies by firms. Their investigations lay the foundation for the assertion that firms endowed with robust innovation capabilities exhibit greater potential to sustain financial performance when implementing pollution prevention strategies (King & Lenox, 2002). The NRBV also supports the concept of clean technology, as evidenced by the research conducted by Hart (1995) posits that although pollution prevention and product stewardship contribute to environmental performance, firms need to mitigate their energy consumption by embracing strategies involving clean technology. Consequently, these firms can gain a competitive edge by embracing clean technologies and abstaining from practices detrimental to the environment (Meurig Thomas & Raja, 2005). Hart (1997) clearly differentiated between "greening" strategies, encompassing pollution prevention and product stewardship, and "beyond greening" strategies, involving clean technology and sustainable development. This distinction allows firms to orient themselves toward a sustainable future and enhance their environmental performance. Lately, the escalating entrepreneurial activity has heightened scholarly interest in clean and green technology (Haque, 2022; Wei et al., 2023). Barney et al. (2010) assert that the cultivation of clean technology necessitates a focus on innovation. Building on this premise, the present study conceptualizes GIC as an implicit resource and an ever-evolving dynamic capability for manufacturing firms. Within this framework, organizations aspiring to amplify the influence of GIC on GSE and subsequently on environmental performance stand to gain a competitive advantage that may prove challenging for their counterparts to replicate or pursue. Furthermore, it provides an avenue for manufacturing firms to continually fortify their competitive edge by acquiring knowledge through GMI and empowering their GSE. This involves leveraging the organization's GTI and GTL to mitigate the adverse effects of manufacturing processes on the environment and contribute to environmental regeneration.

Relationships between Green Factors and Environmental Performance

The study Nisar et al. (2021) suggests that the incorporation of green human resource practices, encompassing green innovation and development, along with the management of green discipline, serves as a substantial predictor for the cultivation of green intellectual capital. This, in turn, makes a constructive contribution to the advancement of pro-environmental performance. The study Nisar et al. (2021) illustrates that green human resource management practices indirectly influence environmental performance by fostering the development of GIC and encouraging pro-environmental behaviours. The study Abu Seman et al. (2019) reveal a significant and positive correlation between GSCM, encompassing both green innovation and environmental performance. Moreover, the findings indicate that GI has a positive impact on environmental performance. Additionally, the study unveils that Green Innovation acts as a mediator in the connection between Green Supply Chain Management and environmental performance (Abu Seman et al., 2019).

The incorporation of these practices compels organizations to strengthen and sustain their relationships with suppliers and customers, with the goal of attaining elevated environmental performance (Abeysundera, 2022). This involves the oversight and control of suppliers to guarantee the supply of environmentally friendly materials, thereby mitigating adverse environmental impacts during production processes. Concurrently, organizations endeavour to satisfy customer preferences for environmentally sustainable products. Furthermore, Green Management Innovation is instrumental in cultivating environmental performance (Abeysundera, 2022). Innovation in green technology functions as a medium or mechanism through which financial influences shape and alter environmental and energy-related performance. This process entails the application of state-of-the-art technological advancements, breakthroughs, and strategies specifically crafted to advance environmental sustainability and enhance efficiency in the energy sector (Cao et al., 2021). The process involves integrating financial strategies and instruments to incentivize the development and adoption of environmentally sustainable

technologies, ultimately resulting in enhanced energy efficiency and a reduced ecological footprint. Singh et al. (2020) propose that the association between GTL and GI is mediated by the implementation of HRM practices. This indicates that the impact of Green HRM on the environmental performance of businesses occurs indirectly through its influence on Green Innovation. Moreover, it underscores the idea that the relationship between HRM and performance relies not solely on the additive or interactive effects of Green Innovation and Green Transformational Leadership, but rather on their combined influence, ultimately enhancing firm environmental performance. In conclusion, this highlights the pivotal role of leadership in shaping HRM practices, which, in turn, impact green innovation within businesses. Considering the above discussion, the formulation of the following hypotheses is plausible:

H1: *There is a positive relationship between GIC and EP.*
H2: *There is a positive relationship between GMI and EP.*
H3: *There is a positive relationship between GTI and EP.*
H4: *There is a positive relationship between GTL and EP.*

Green Self-Efficacy as a Mediator

GSE represents a manifestation of self-awareness that positively impacts both pro-environmental behaviour and enduring performance. The augmentation of GSE is anticipated to be a catalyst for enhanced sustainable performance (Obeidat et al., 2020). Warith (2019) propose that GSE possesses the capacity to stimulate an individual's environmental attitudes and perspectives, thereby fostering the adoption of pro-environmental practices. Nisar et al. (2021) suggests that exploring moderating variables, such as GSE, provides an intriguing avenue for research beyond the direct relationship between pro-environmental behaviour and GIC. Therefore, a critical variable that may influence the nature and extent of the association between GIC and pro-environmental behaviour is GSE. The study Javaid et al. (2023) suggest that the attainment of sustainable development, especially in developing nations, is significantly contingent on the acquisition of environmental knowledge. Remarkably, there is a limited body of research that has investigated the role of green self-efficacy as a mediator within the context of sustainable performance and environmental knowledge. The study Zhang et al. (2020a) suggest that both GTL and GSE possess the capability to augment the performance of green product development. In particular, GSE functions as a mediator in the positive correlation between GTL and the performance of green product development. Moreover, environmental regulation positively moderates the mediating influence of GSE. Furthermore, the interplay between environmental regulation and GSE collectively promotes the advancement of green product development performance (Zhang et al., 2020a). GTL cultivates the enhancement of employees' GSE through the establishment of achievable environmental objectives, delineation of environmental benchmarks, cultivation of an environmental ethos, and alignment of individual behaviour with desired outcomes (Chen et al., 2015).

Individuals exhibiting elevated levels of GESE tend to be predisposed toward fostering innovative concepts, conceptualizing creatively environmentally friendly products and services, and demonstrating a strong sense of social responsibility towards environmental preservation. This disposition enables enterprises to attain a competitive advantage, resulting in enhanced economic performance and increased profitability (Chu et al., 2021). Within the association between GTL and employees' environmentally conscious attitudes and behaviours, GSE assumes a pivotal mediating role. Operating as a psychological mechanism, GSE facilitates the absorption of the direction and motivation provided by GTL, empowering and instilling confidence in staff members to actively engage in sustainable activities and endorse the company's environmental initiatives (Huang et al., 2023). Based on the foregoing discussion, the following hypotheses can be posited:

H5: *GSE mediates the relationship between GIC and EP.*
H6: *GSE mediates the relationship between GMI and EP.*
H7: *GSE mediates the relationship between GTI and EP.*
H8: *GSE mediates the relationship between GTL and EP.*

Green Empowerment's Moderating Role

The term "green empowerment," derived from the contextual framework, denotes a comprehensive strategy encompassing all organizational initiatives aimed at cultivating an environmentally conscious work culture among employees. It involves the deliberate development, implementation, and continuous maintenance of programs and systems that promote ecologically friendly behaviour among employees. The integration of environmental management considerations and values into human resources management strategies has the potential to reduce employee carbon footprints, fostering increased efficiency and improved environmental performance (Adi et al., 2021). The study Ojo et al. (2022) suggest that the implementation of green training and development, performance management, as well as empowerment and participation programs is essential to enhance pro-environmental performance. The study Ahuja et al. (2023) indicates that the relationship between millennial employee retention and three GHRM practices—green rewards, green performance management, and green training—is substantially moderated by empowerment. This implies that the efficacy of these GHRM practices in retaining millennial workers is contingent on the level of empowerment among employees. The study also elucidates the positive mediation of employee green empowerment in the relationships between GHRM practices, customer environmental collaboration, and environmental performance (Hutomo et al., 2020). In the current study, it is asserted that green empowerment serves as a moderator in the relationship between GSE and EP.

According to Hameed et al. (2020), Green HRM practices employ green employee empowerment as a mediator. This study investigates the impact of green empowerment on the relationship between environmental performance and green self-efficacy. The study (Nisar et al., 2022) elucidates the correlation between the human resources department and the promotion of employees' GSE, underscoring their role in facilitating contributions to enhance EP. Consequently, the following hypothesis is posited:

H9: *GE moderates the relationship between GSE and EP.*

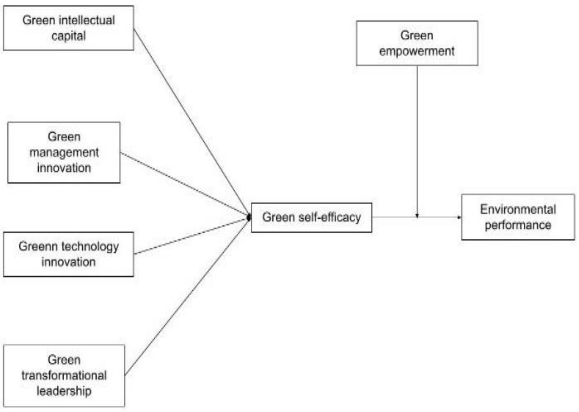

Figure 2.1. Conceptual Framework

3. Method

Research Design

This study primarily concentrates on examining the influence of GIC, GMI, GTI and GTL on EP, elucidating the causal relationships between these variables. Consequently, the positivist research philosophy was employed in this study (Alharahsheh & Pius, 2020). However, this study incorporates a mediation-moderation model, underscoring the integration of objectivism. Therefore, a deductive approach was employed. The quantitative methodology, specifically a cross-sectional approach, was chosen for data collection through surveys to ascertain the cause-and-effect relationships among the study constructs. Subsequently, statistical analysis was conducted to test the hypotheses.

Participants and Sampling

This study primarily centres on assessing the influence of GTI and leadership on environmental performance within the framework of the manufacturing sector in Saudi Arabia. Consequently, the most appropriate population for this study comprises employees from various manufacturing firms in Saudi Arabia. It is anticipated that in 2023, the workforce in Saudi Arabia's manufacturing sector will witness an increment of 1,190,000 employees (Statista, 2023). The extensive size of the population posed a challenge for the researcher in data collection. Consequently, random sampling was employed to mitigate research bias, resulting in the selection of a final sample of 210 participants for this study.

Data Collection Route

This study employed an online survey to gather the necessary data from the chosen sample size. The questionnaire devised for the survey comprised two sections. Section I encompassed participant demographics, encompassing age, gender, and education. Section II comprised questions related to the constructs under investigation in the study.

Participant confidentiality was diligently preserved throughout this study, with individuals afforded complete autonomy regarding their participation. This approach fostered a productive relationship between the researcher and participants, enhancing the credibility of the outcomes. Additionally, the researcher upheld the integrity of the collected data, ensuring the absence of research bias. Table 3.1 provides an overview of the measures employed in this study.

Table 3.1. Measures

Variables	Items	Adapted from	References	Scale
GIC	5	(Chen, 2008)	(Chen, 2008)	5-point Likert scale ("1= strongly agree to 5= strongly disagree")
GMI	6	(Banerjee, 2002; Hong et al., 2009; Peng & Lin, 2008)	(Zhou et al., 2019)	
GTI	5	(Huang & Li, 2017; Singh & El-Kassar, 2019)	(Sahoo et al., 2023)	
GTL	6	(Chen & Chang, 2013)	(Al-Ghazali et al., 2022)	
EP	5	(Huang & Li, 2017; Vanalle et al., 2017)	(Sahoo et al., 2023)	
GSE	6	(Chen et al., 2015)	(Mughal et al., 2022)	
Green empowerment	8	(Yu et al., 2011)	(Farheen et al., 2020)	

Statistical Analysis Technique

In this study, statistical analysis was undertaken using SPSS to ascertain both descriptive and inferential statistics. ANOVA was employed to assess the model's adequacy, and regression analysis was conducted to test the formulated hypotheses.

4. Results

Demographics of Participants

The demographic profile of the study revealed that 40% of the selected participants were female, whereas 60% were male. Regarding age distribution, 30% fell within the bracket of 25 to 30 years, 50% were aged between 31 and 35 years, and 20% were above 35 years of age. In terms of education, 50% of the participants had completed their undergraduate studies, while the remaining 50% held postgraduate degrees.

Descriptive Statistics

Table 4.1 presents the descriptive statistics for the current study, indicating data collection from a participant pool of 210 individuals. The minimum and maximum values for each variable were observed to be 1 and 5, respectively. Notably, the mean values for each variable exceeded 3, signifying substantial outcomes. Furthermore, the skewness values fell within the range of -1 to +1, indicating statistically significant results.

Table 4.1. Descriptive Statistics

Descriptive Statistics							
	N	Min	Max	M.	Std. Dev.	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
EP	210	1.00	5.00	3.8012	.94372	-1.178	.168
GIC	210	1.20	5.00	3.7476	.94869	-.997	.168
GTI	210	1.20	5.00	3.7286	.86375	-.851	.168
GMI	210	1.00	5.00	3.4657	1.03511	-.396	.168
GE	210	1.00	5.00	3.2327	.80114	-.242	.168
GTL	210	1.00	5.00	3.7540	.90221	-1.213	.168
GSE	210	1.00	5.00	3.7913	1.12293	-.879	.168
Valid N (listwise)	210						

Max= maximum, m= mean, min= minimum, EP= environmental performance, GIC= green intellectual capital, GTI= green technology innovation, GMI= green management innovation, GE= green empowerment, GTL= green transformational leadership, GSE= green self-efficacy

Correlation Analysis

Table 4.2 displays the results of the correlation analysis in this study, illustrating the associations between various variables. The observed significance level for each correlation was less than 0.01, indicating the statistical significance of the relationships between the variables. Consequently, the data was deemed suitable for further analysis.

Table 4.2. Correlation Analysis

		EP	GIC	GTI	GMI	G_E	GTL	GSE
EP	PC	1	.834**	.785**	.698**	.670**	.915**	.747**
	Sig. (2-tail)		.000	.000	.000	.000	.000	.000
	N	210	210	210	210	210	210	210
GIC	PC	.834**	1	.730**	.610**	.680**	.848**	.804**
	Sig. (2-tail)	.000		.000	.000	.000	.000	.000
	N	210	210	210	210	210	210	210
GTI	PC	.785**	.730**	1	.686**	.631**	.780**	.681**
	Sig. (2-tail)	.000	.000		.000	.000	.000	.000
	N	210	210	210	210	210	210	210
GMI	PC	.698**	.610**	.686**	1	.505**	.617**	.580**
	Sig. (2-tail)	.000	.000	.000		.000	.000	.000
	N	210	210	210	210	210	210	210
GE	PC	.670**	.680**	.631**	.505**	1	.624**	.684**
	Sig. (2-tail)	.000	.000	.000	.000		.000	.000
	N	210	210	210	210	210	210	210
GTL	PC	.915**	.848**	.780**	.617**	.624**	1	.721**
	Sig. (2-tail)	.000	.000	.000	.000	.000		.000
	N	210	210	210	210	210	210	210
GSE	Pearson Correlation	.747**	.804**	.681**	.580**	.684**	.721**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	210	210	210	210	210	210	210

**. Correlation is significant at the 0.01 level (2-tailed).
EP= environmental performance, GIC= green intellectual capital, GTI= green technology innovation, GMI= green management innovation, GE= green empowerment, GTL= green transformational leadership, GSE= green self-efficacy; PC= Pearson Correlation; Tail= tailed

Model Summary

The R square in the model summary represents the percentage of variance contributed by the predictors to the dependent variable in this study. As indicated in Table 4.3, the predictors account for 87.1% of the variance in the associated dependent variable.

Table 4.3. Model Summary

Model	R	R Square	Adj. R Square	Std. Error of the Estimate
1	.935[a]	.874	.871	.33840

a. Predictors: (Constant), GTL, GMI, GTI, GIC, adj= adjusted

ANOVA

To assess the fitness and adequacy of the model in the current research, ANOVA was employed to ascertain differences between the means of the relevant variables. As depicted in Table 4.4, the F-value for the model was 355.103, and the significance level was below 0.01, affirming the suitability of the model for further analysis.

Table 4.4. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	162.661	4	40.665	355.103	.000[b]
	Residual	23.476	205	.115		
	Total	186.137	209			

a. Dependent Variable: EP
b. Predictors: (Constant), GTL, GMI, GTI, GIC

Direct Results

Table 4.5 presents the outcomes of the direct associations between the variables. It was noted that GIC, GMI, and GTL exhibited a significant impact on EP, as evidenced by p-values less than 0.05. However, GTI showed an insignificant impact on EP.

Table 4.5. Direct Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.044	.109		-.409	.683
	GIC	.135	.048	.136	2.814	.005
	GTI	.074	.048	.068	1.547	.123
	GMI	.159	.032	.174	4.971	.000
	GTL	.669	.055	.640	12.237	.000

a. Dependent Variable: EP

EP= environmental performance, GIC= green intellectual capital, GTI= green technology innovation, GMI= green management innovation, GTL= green transformational leadership

Mediation Analysis

Table 4.6 outlines the findings regarding the mediating impact of GSE. It was noted that GSE significantly mediates the association between GIC and EP, GTI and EP, GMI and EP, as well as between GTL and EP ($p < 0.05$). The lower and upper values for each mediation ranged between.50 and.960. However, for the GSE mediation between GTL and EP, the lower value was.900, and the upper value was 1.015.

Table 4.6. Mediation Analysis

Relationship	T. E	D.E	I.E	Confidence Interval		t statistics	*p* value	Conclusion
				L bound	U bound			
GIC→GSE→EP	.8297	.6562	.1735	.7546	.9047	21.8025	.0000	Accepted
GTI→ GSE → EP	.8582	.5636	.9506	.7658	.9506	18.3043	.0000	Accepted
GMI→ GSE → EP	.6365	.3637	.2729	.5473	.7258	14.0651	.0000	Accepted
GTL→ GSE → EP	.9575	.8209	.1367	.9000	1.0151	32.7965	.0000	Accepted

T. E= total effect; D. E= direct effect; I. D= indirect effect; L= lower; U= upper

Moderation Analysis

Table 4.9 presents the outcomes of the moderating impact analysis of GE in the association between GSE and EP. It was observed that GE exerts a significant moderating impact in the association between GSE and EP ($p < 0.05$).

Table 4.9. Moderation Analysis

Model							
	coeff	se	t	*p*	LLCI	ULCI	Conclusion
constant	-.9189	.4487	-2.0478	.0418	-1.8035	-.0342	Accepted
GSE	.9700	.1249	7.7644	.0000	.7237	1.2163	
GE	1.0878	.1787	6.0873	.0000	.7355	1.4401	
Int_1	-.1923	.0432	-4.4529	.0000	-.2774	-.1071	

5. Discussion

This study primarily seeks to investigate the influence of green innovation and leadership on the EP within the manufacturing sector in Saudi Arabia. The mediating role of GSE was incorporated into the analysis, along with the observation of the moderation effect of green empowerment. Quantitative data were gathered from 210 employees through a survey method, and subsequent statistical analysis yielded four significant findings from this study.

Initially, noteworthy findings indicate that GMI, GTL, and GIC significantly influence EP, corroborating Hypotheses 1, 2, and 4. These results underscore the pivotal role of human capital and management in enhancing the EP of manufacturing firms in Saudi Arabia. Notably, the incorporation of GTL at the executive level is identified as crucial in motivating employees to engage in environmentally friendly practices, thus contributing to substantial sustainable outcomes and bolstering the company's social and sustainable image. This result underscores the critical imperative for manufacturers in Saudi Arabia to acknowledge the significance of incorporating and promoting green management practices, exemplified by GMI, and integrating GTL within the organizational framework. Furthermore, it highlights the strategic necessity for prioritizing environmentally friendly manufacturing processes and cultivating green leadership to augment the environmental performance of organizations. Additionally, it emphasizes the need for the manufacturing sector in the Kingdom of Saudi Arabia (KSA) to proactively develop leaders by investing in programs aimed at enhancing leaders' environmental consciousness and green knowledge. Such empowerment of leaders would enable the implementation of green initiatives and the promotion of eco-friendly practices within the organization. The manufacturing sector's focus on green initiatives is instrumental in fostering a culture of sustainability, thereby positively influencing its environmental performance. This strategic approach aligns with the global emphasis on eco-conscious manufacturing practices and can contribute to organizations gaining a competitive edge in the environmentally conscious global market. Moreover, the study's revelations concerning the positive impact of GIC on environmental performance underscore the importance of investing in knowledge and intellectual resources dedicated to promoting environmental sustainability. The manufacturing sector in Saudi Arabia should prioritize the cultivation of its intellectual capital to foster a culture of green practices in the manufacturing process. This can be achieved through the implementation of a learning culture, providing training to employees in terms of environmental consciousness and green behaviour. This transformation of the human resource of the firms into a form of GIC aims at fostering innovative and sustainable manufacturing processes. Consequently, the manufacturing sector can enhance its intellectual capital by incorporating green values, positioning itself more competitively in the global market. Such an approach not only improves the global image of associated companies but also serves as

motivation for other firms to integrate GMI, GTL, and GIC to enhance their EP (Yin et al., 2022).

Secondly, it is evident that GTI does not exhibit a significant association with EP, thereby rejecting Hypothesis 3. This outcome suggests that, despite the ongoing technological advancements, numerous manufacturing firms in Saudi Arabia face challenges in adapting to these technologies, consequently constraining their overall performance in this domain. Furthermore, the successful integration of advanced and innovative green technologies necessitates a skilled and technical workforce. The absence of such technical capabilities can thereby exert a negative impact on the EP of the affiliated firms (Zhang et al., 2020b). Nevertheless, several manufacturing firms in Saudi Arabia remain steadfast in their commitment to enhancing GTI to gain a competitive advantage, leading to increased social and financial benefits. The rejection of Hypothesis 3 underscores the imperative for manufacturers in the Kingdom of Saudi Arabia (KSA) to reassess their innovation strategies, particularly those related to the incorporation of green technology. The absence of a significant correlation between GTI and EP in the context of the current study's findings also implies that the sole investment in GTI may not suffice to improve the EP of manufacturing firms. Other factors may be at play in influencing the Environmental Performance of the manufacturing sector in the KSA.

Thirdly, it is noteworthy that GSE exhibits a significant mediating effect, affirming Hypotheses 5, 6, 7, and 8. In accordance with self-determination theory, individuals with heightened self-determination also demonstrate elevated self-efficacy, thereby motivating them to optimize their performance (Gagné et al., 2022). Thus, in the context of this study, individuals with elevated GSE were more inclined to execute green tasks with greater efficiency, thereby contributing to the enhancement of their firms' EP. Robust GSE not only serves as a motivator for employees but also encourages both employees and management to integrate GTI and GMI to elevate the firm's EP. Conversely, individuals with lower GSE demonstrated less motivation to advocate for green technology and management, resulting in a negative impact on EP. Therefore, it is imperative to enhance GSE among employees, fostering a collaborative effort to improve the firm's EP. This discovery underscores the critical importance of implementing employee training programs specifically designed to augment GSE within the manufacturing sector. Such programs can aid in developing a workforce with heightened environmental awareness and GSE, thereby assisting the organization in elevating its EP and achieving sustainability objectives. Additionally, this finding implies that leaders should possess adept skills to influence and shape the GSE of employees, subsequently enhancing the overall EP of the organization.

Fourthly, it is evident that Green Empowerment exerts a significant moderating effect on the association between GSE and EP, confirming Hypothesis 9. Green empowerment contributes to enhancing the collective capability of employees to implement green and sustainable strategies, thereby positively impacting the EP of the firm. This approach also serves to elevate GSE among employees, improving their overall sustainable performance and potentially providing the associated company with a competitive advantage. Conversely, the absence of green empowerment can detrimentally affect the overall GSE of employees, hindering their optimal performance within the context of the firm's EP. The validation of Hypothesis 9 underscores the imperative for the manufacturing sector in the Kingdom of Saudi Arabia to prioritize the reinforcement of employees' green empowerment. This reinforcement can empower employees to manifest green behaviour and actively participate in the organization's green initiatives. Achieving this entails granting employees autonomy in the execution of green initiatives. Consequently, the organizational emphasis on implementing green empowerment measures among employees has the potential to enhance their GSE and subsequently elevate the EP of the organization.

6. Conclusion

The escalating global concern over climate change has spurred various sectors to address the emission of toxic gases. In response, the manufacturing sector has undergone significant transformation through the adoption of green innovation, underscoring the importance of integrating green technology innovation and transformational leadership. The implementation of green technology and management is paramount for mitigating climate change. However, the significance of GSE and green empowerment among employees within this sector is also crucial to ensuring the effective EP of the firm. Thus, this study delves into the impact of GTI and leadership on EP within the specific context of the manufacturing sector in Saudi Arabia. This study has specifically examined the influence of GSE and Green Empowerment among employees in the manufacturing sector on the EP of firms. The findings from this study reveal that GTI has a negligible impact on EP, whereas GMI, GTL, and GIC significantly influence EP. Furthermore, the mediating role of GSE was deemed significant, and the moderating impact of green empowerment was also found to be significant.

7. Research Implications

Theoretical Implications

Presently, considerable attention is devoted to environmental literature, investigating the impact of GTI and management on enhancing the sustainable performance of affiliated firms. Consequently, the current research makes a notable contribution to the existing body of knowledge on GTI and environmental literature, with a specific emphasis on the role of GTL. This contribution holds potential for elevating public awareness and informing stakeholders about the pivotal role of GTL in enhancing EP. Furthermore, the study highlights the innovative aspect of exploring the moderating influence of green empowerment in the relationship between GSE and

EP, adding a layer of novelty and overall value to the research. Thus, the present study underscores the advocacy for green management promotion as a means to enhance EP, fostering increased environmental sustainability within the environmental sector.

Practical Implications

The findings derived from this study are poised to serve as a catalyst for management across diverse manufacturing firms, motivating them to formulate and implement robust green technology and strategies aimed at enhancing the firms' EP. Simultaneously, this research holds the potential to inspire various stakeholders to adopt green management practices to elevate EP, with a specific emphasis on the integration of GTL. Furthermore, the study is anticipated to stimulate governmental bodies to develop new and impactful green initiatives for bolstering environmental sustainability. Such initiatives could pave the way for the formulation and execution of effective green policies and strategies in the manufacturing sector, ultimately yielding positive environmental outcomes.

8. Limitations and Future Research Directions

This study encompasses several limitations that may affect its robustness. Firstly, the exclusive focus on the manufacturing sector to assess the influence of green technology innovation on EP was driven by the ease of data accessibility, potentially limiting the generalizability of findings to other sectors. Additionally, the inclusion of only one mediator in the study was necessitated by constraints within the existing literature. Moreover, the cross-sectional nature of the study, dictated by the constraints of a shorter timeframe, may impact the ability to establish causal relationships and temporal dynamics.

Subsequent research endeavours could broaden the scope by exploring alternative sectors, including but not limited to the construction and fashion industries, to elucidate the impact of green technology innovation. Furthermore, enriching the conceptual framework by introducing additional mediators like green supply chain management and strategic agility would contribute to understanding the linkage between GMI and EP. Additionally, future research may benefit from longitudinal studies within this context to offer deeper insights into the dynamics over time.

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Appendix A

Measurement Tool	References
Green Management Innovation	
Our company protects the environment. Our company respects natural laws. We maintain an ethical working environment. We utilize resources wisely and responsibly. We economize in the usage of raw materials. We recycle our products.	(Banerjee, 2002; Hong et al., 2009; Peng & Lin, 2008)
Green Technology Innovation	
Our organization continuously optimizes the manufacturing and operational processes by using cleaner methods or green technologies to make savings. Our organization is actively involved in the redesign and improvement of products or services in order to comply with existing environmental or regulatory requirements. Our organization specializes in recycling practices to ensure that end-of-life products are recovered for reuse in new product manufacturing. Our organization is rigorously involved in "eco-labeling" activities to make our clients conscious of our sustainable management practices. The Research & Development team at our organization ensures that the current technical advancement is included in the development of new eco-products.	(Huang & Li, 2017; Singh & El-Kassar, 2019)
Green Self-Efficacy	
We feel we can succeed in accomplishing environmental ideas; We can achieve most of environmental goals We feel competent to deal effectively with environmental tasks We can perform effectively on environmental missions. We can overcome environmental problems. We could find out creative solutions to environmental problems.	(Chen et al., 2015)
Green Transformational Leadership	
The leader of the green product development project inspires the project members with the environmental plans at our company. The leader of the green product development project provides a clear environmental vision for the project members to follow at our company. The leader of the green product development project gets the project members to work together for the same environmental goals at our company. The leader of the green product development project encourages the project members to achieve the environmental goals at our company. The leader of the green product development project acts with considering environmental beliefs of the project members at our company. The leader of the green product development project stimulates the project members to think about green ideas at our company.	(Chen & Chang, 2013)
Green Intellectual Capital (proxy= Green Human Capital)	
The productivity and contribution of environmental protection of the employees in the firm is better than those of its major competitors The employees' competence of environmental protection in the firm is better than that of its major competitors The product or service qualities of environmental protection provided by the employees of the firm are better than those of its major competitors The cooperative degree of team work about environmental protection in the firm is more than that of its major competitors The managers can fully support their employees to achieve their jobs of environmental protection	(Chen, 2008)
Green Empowerment (proxy= employee empowerment)	
I am allowed to be creative when Ideal with environmental problems. I am allowed to do anything to do a high-quality sustainable job. I don't need to get management approval before I handle environmental problems. I rely heavily on instructions and on the system. I can't take charge of problems that require immediate attention. I feel competent to perform the green tasks required for my position My manager trusts me to make appropriate sustainable decisions in my job. I have considerable opportunity for interdependence and freedom in how I do my job.	(Yu et al., 2011)
Environmental Performance	
Reduction of air emission. Reduction of waste water. Reduction of solid wastes. Decrease of consumption for hazardous/harmful/toxic materials. Improve[ments] in [the] companys environmental situation.	(Huang & Li, 2017; Vanalle et al., 2017)